CLAIMS

1. A method for fine synchronization of a digital telecommunication receiver, comprising a code tracking process for maintaining fine alignment between an incoming spread spectrum signal and a locally generated code, said method comprising:
- storing a plurality of consecutive samples (E-1, E, M, L, L+1) of said incoming spread spectrum signal in a delay line (56);
- determining by interpolation between consecutive samples of said incoming spread spectrum signal, by means of a first (26) digitally controlled interpolator, an interpolated early sample (e) anticipating an optimal sampling time instant;
- determining by interpolation between consecutive samples of said incoming spread spectrum signal, by means of a second (24) digitally controlled interpolator, an interpolated middle sample (m) corresponding to said optimal sampling time instant;
- determining by interpolation between consecutive samples of said incoming spread spectrum signal, by means of a third (28) digitally controlled interpolator, an interpolated late sample (l) delayed with respect to said optimal sampling time instant;
- calculating an error signal (ξ) as the difference between the energy of the symbols computed from said interpolated early (e) and late (l) samples;
characterised in that said method further comprises the following steps:
- extracting the sign of said error signal (ξ);
- accumulating said sign of said error signal (ξ) for the generation of control signals (S_E, S_M, S_L) for controlling the interpolation phases of said digitally controlled interpolators;
wherein the time distance between said interpolated early (e) and late (l) samples varies in relation with a first of said control signal (S_M), and the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is lower than the time resolution used for determining by interpolation said middle interpolated sample (m).

2. A method according to claim 1, wherein said step of accumulating said sign of said error signal (ξ) provides that the value accumulated has a positive saturation value of +4 and a negative saturation value of -4.

3. A method according to claim 1 or 2, wherein the time distance between said interpolated early (e) and late (l) samples assumes, alternatively, a value of T_C, where

T_C is the period of an elementary waveform, when said first control signal (S_M) is an even value, or a value of $3 \cdot T_C/4$ when said first control signal (S_M) is an odd value.

4. A method according to claim 2, wherein a second control signal (S_B), for controlling said first digitally controlled interpolator (26), is generated as a function of said first control signal (S_M), according to the formula:

$$S_B = \left\lfloor \frac{S_M}{2} \right\rfloor$$

where the function $\lfloor \cdot \rfloor$ approximates the argument to the nearest lower integer.

5. A method according to claim 2, wherein a third control signal (S_L), for controlling said third digitally controlled interpolator (28), is generated as a function of said first control signal (S_M), according to the formula:

$$S_L = \left\lfloor \frac{S_M + 1}{2} \right\rfloor$$

where the function $\lfloor \cdot \rfloor$ approximates the argument to the nearest lower integer.

6. A method according to claim 1, wherein the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is half than the time resolution used for determining by interpolation said middle interpolated sample (m).

7. A method according to claim 6, wherein said plurality of consecutive samples (E-1, E, M, L, L+1) are time spaced of $T_C/(2 \cdot n)$, where T_C is the period of an elementary waveform and n is an integer, the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is $T_C/(4 \cdot n)$ and the time resolution used for determining by interpolation said middle interpolated sample (m) is $T_C/(8 \cdot n)$.

8. A method according to claim 6, wherein said plurality of consecutive samples (E-1, E, M, L, L+1) are time spaced of $T_C/2$, where T_C is the period of an elementary waveform, the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is $T_C/4$ and the time resolution used for determining by interpolation said middle interpolated sample (m) is $T_C/8$.

9. A digital communication receiver comprising a device for maintaining fine alignment between an incoming spread spectrum signal and a locally generated code, said device comprising:

- a delay line (56) for storing a plurality of consecutive samples (E-1, E, M, L, L+1) of said incoming spread spectrum signal;

- a first digitally controlled interpolator (26) for determining by interpolation between consecutive samples stored in said delay line (56) an interpolated early sample (e) anticipating an optimal sampling time instant;

- a second digitally controlled interpolator (24) for determining by interpolation between consecutive samples stored in said delay line (56) an interpolated middle sample (m) corresponding to said optimal sampling time instant;

- a third digitally controlled interpolator (28) for determining by interpolation between consecutive samples stored in said delay line (56) an interpolated late sample (l) delayed with respect to said optimal sampling time instant;

- at least a correlator (30, 32, 22) for calculating an error signal (ξ) as the difference between the energy of the symbols computed from said interpolated early (e) and late (l) samples;

characterised in that said device further comprises:

- a circuit (23) for extracting the sign of said error signal (ξ);

- a control signal generator (66) for accumulating said sign of said error signal (ξ) in a register for the generation of control signals (S_E, S_M, S_L) for controlling the interpolation phases of said first (26), second (24) and third (28) digitally controlled interpolators;

wherein the time distance between said interpolated early (e) and late (l) samples varies in relation with a first of said control signals (S_M), and the time resolution of said first (26) and third (28) digitally controlled interpolators is lower than the time resolution of said second (24) digitally controlled interpolator.

10. A digital communication receiver according to claim 9, wherein said register in which is accumulated the sign of said error signal has a positive saturation value of +4 and a negative saturation value of -4.

11. A digital communication receiver according to claim 9 or 10, wherein the time distance between said interpolated early (e) and late (l) samples assumes, alternatively, a value of T_C, where T_C is the period of an elementary waveform, when said first control

signal (S_M) is an even value, or a value of $3 \cdot T_C/4$ when said first control signal (S_M) is an odd value.

12. A digital communication receiver according to claim 10, wherein a second control signal (S_B), for controlling said first digitally controlled interpolator (26), is generated as a function of said first control signal (S_M), according to the formula:

$$S_B = \left\lfloor \frac{S_M}{2} \right\rfloor$$

where the function $\lfloor \cdot \rfloor$ approximates the argument to the nearest lower integer.

13. A digital communication receiver according to claim 10, wherein a third control signal (S_L), for controlling said third digitally controlled interpolator (28), is generated as a function of said first control signal (S_M), according to the formula:

$$S_L = \left\lfloor \frac{S_M + 1}{2} \right\rfloor$$

where the function $\lfloor \cdot \rfloor$ approximates the argument to the nearest lower integer..

14. A digital communication receiver according to claim 9, wherein the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is half than the time resolution used for determining by interpolation said middle interpolated sample (m).

15. A digital communication receiver according to claim 14, wherein said plurality of consecutive samples (E-1, E, M, L, L+1) are time spaced of $T_C/(2 \cdot n)$, where Tc is the period of an elementary waveform and n is an integer, the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is $T_C/(4 \cdot n)$ and the time resolution used for determining by interpolation said middle interpolated sample (m) is $T_C/(8 \cdot n)$.

16. A digital communication receiver according to claim 14, wherein said plurality of consecutive samples (E-1, E, M, L, L+1) are time spaced of $T_C/2$, where Tc is the period of an elementary waveform, the time resolution used for determining by interpolation said interpolated early (e) and late (l) samples is $T_C/4$ and the time

resolution used for determining by interpolation said middle interpolated sample (m) is $T_C/8$.

17. A digital communication receiver according to claim 9 or 10, wherein said delay line (56) stores five consecutive samples (E-1, E, M, L, L+1) of said incoming spread spectrum signal.

18. A digital communication receiver according to claim 17, wherein said first digitally controlled interpolator (26), which is controlled by said second (S_E) control signal, receives in input the first three samples (E-1, E, M) stored in said delay line (56), and generates said interpolated early sample (e) as a function of said second control signal (S_E) and said first three samples (E-1, E, M).

19. A digital communication receiver according to claim 17, wherein said second digitally controlled interpolator (24), which is controlled by said first (S_M) control signal, receives in input the three middle samples (E, M, L) stored in said delay line (56) and generates said interpolated middle sample (m) as a function of said first control signal (S_M) and said three middle samples (E, M, L).

20. A digital communication receiver according to claim 17, wherein said third digitally controlled interpolator (28), which is controlled by said third (S_L) control signal, receives in input the last three samples (M, L, L+1) stored in said delay line (56) and generates said interpolated late sample (l) as a function of said third control signal (S_L) and said last three samples (M, L, L+1).

21. A digital communication receiver according to claim 9, wherein said first digitally controlled interpolator (26) and said third digitally controlled interpolator (28) are realized as a single time multiplexed digitally controlled interpolator, the interpolated early (e) and the interpolated late (l) samples being computed at different time intervals.